SERVICE INSTRUCTIONS

148-032

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section DB

REMOTELY PROGRAMMABLE DIGIT-INSERTION UNIT, RDI-1

P/N 1160-4005

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SECTION **DB-1**

INTRODUCTION

DB-1.1 GENERAL.

The information contained in this section supplements the over-all operation and instrument-maintenance instructions that appear in the front of this manual. This section is prepared from a modular point of view. It is intended to furnish detailed information necessary for proper field maintenance (in the event of module failure), as indicated by paragraph 5.6 "System Trouble-Analysis."

Included in the following paragraphs are a physical description and signal-flow discussion of the module sufficient for comprehension by experienced service personnel of the principles of operation. A trouble-analysis procedure that will aid in isolation of defective circuits completes the section.

To facilitate part identification, reference designators used in the text and appearing on the photographs are the same as those used on the complete schematic diagram and in the parts list.

The service instructions rely on the use of a properly functioning synthesizer as a basic test frame for an individual module. The instrument can be used to support the module, in a convenient bench-service position, and to supply it with power and test signals.

NOTE

First consideration should be given to the use of the widespread General Radio Company service organization to repair a defective module, particularly on an instrument still within the two-year warranty.

DB-1.2 PURPOSE.

In General Radio synthesizers, output-frequency generation (remotely programmed, or in accordance with the setting of the front-panel dials) is accomplished by the modules occupying the top of the Main Frame chassis. Of these, the majority are identical and interchangeable and permit selection of crystal-locked frequencies in steps ranging from 0.01 c/s to 100 kc/s, depending on the model and the position of the module. They are called Digit-Insertion units, — DI-1 or RDI-1 for short.

Solid-state circuitry that performs this operation, with the aid of certain fixed direct derivatives of the master crystal oscillator, is self-contained in the RDI-1 package, shown in Figure DB-1. The unit is a convenient plug-in module; all connections to the Main Frame are made automatically as it is installed.

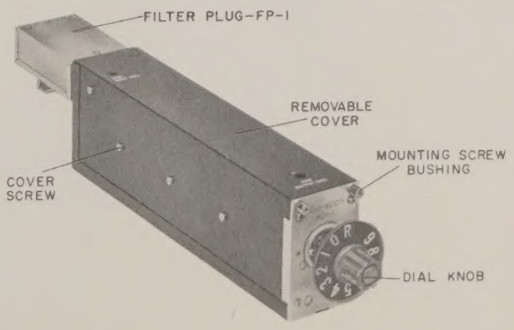

Figure DB-1.
Remotely Programmable Digit-Insertion Unit, RDI-1 (P/N 1160-4005).

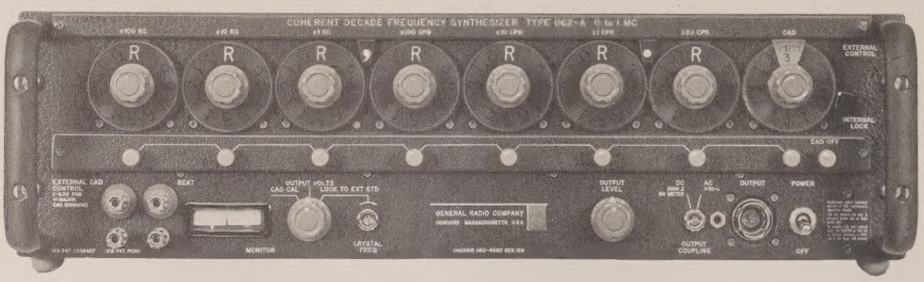

Figure DB-2.
Panel view of the Type 1162-AR7C Coherent Decade Frequency Synthesizer with all digits set for programmable operation.

The RDI-1 Digit-Insertion unit, together with its filter and matrix plug and remote cabling, permits complete or partial remote frequency programming of the GR synthesizer. The RDI-1 can be used in all DI-1 digit stations.

In all cases, it is directly and quickly interchangeable with the DI-1 unit. Control can easily be transferred digit by digit from remote to manual, by means of the front panel dial.

DB-1.3 DESCRIPTION.

The RDI-1 Digit-Insertion unit, with its cover installed, is shown in Figure DB-1. The only external operator control of the unit, the digit-selector switch, is operated by the 1/4-inch shaft and the dial knob visible in front. The ten numbered positions of the dial permit manual frequency selection. The eleventh position, marked "R," transfers control of the frequency setting to the leads in the control cable at the rear of the unit. Figure DB-2 shows a synthesizer with digit-selection controls set for remotely programmable operation.

Connections for remote frequency selection are made through the Filter Plug, FP-1, shown at the rear of the RDI-1 unit in Figure DB-1. Figure DB-3 shows the Filter Plugs connected to the rear of the programmable digit stations of a synthesizer. The Filter Plug engages a printed-circuit connector protruding through the rear wall of the RDI-1 unit and the attaching screw threads into the support bar across the back of the synthesizer.

A small plastic lamp holder, which is part of the RDI-1 as supplied, fits in the synthesizer panel behind the control knob. This holder permits installation of the dial lamp in the instrument front panel, behind the dial, after the RDI-1 has been mounted in the Main Frame (see Figure 5-2 in the systems portion of this manual).

The entire RDI-1 assembly is held in the Main Frame by two 4-40 screws that engage the threaded bushings in the top corners of its small front panel and by a hold-down clamp that secures the reinforced bottom of the cover unit at the rear, through a small cutout.

All electrical connections to the Main Frame except one are made by banana-type plugs through the bottom of the cover into the RDI-1 assembly. The dial lamp is energized and switched in the Main Frame as explained in Section 4.6 (system portion). It can also be controlled from the RDI-1, and this control-signal connection is made by a small pin in the RDI-1 front panel to a spring contact on the instrument front panel. This pin is part of a phase-error sensing circuit that extinguishes the lamp if phase lock is broken.

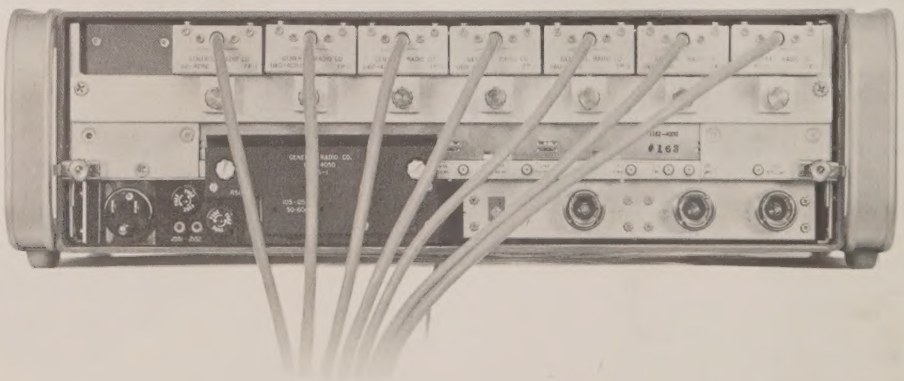

Figure DB-3.
Rear view of the synthesizer of Figure DB-2, showing plug-in filters and remote cabling.

All connections are thus established automatically when the unit is installed.

No. 4-40 screws on either side of the unit fasten the cover to the Digit-Insertion unit frame structure. After their removal, the unit can be withdrawn from the cover, if the case is held in one hand and the unit is pulled by its switch shaft with the other.

The circuitry of the RDI-1 is contained on five etched-circuit boards. They are the long horizontal top and bottom boards and the smaller vertical front and rear circuit boards. These boards mount all components and furnish most of the electrical connections between them. In the bottom board are 6 banana jacks and 2 special ground contacts, which make the electrical connections to the Main Frame mentioned earlier.

Signal flow and circuit layout are so arranged that a minimum of wiring between boards is required and each individual board assembly can be removed from the structure, after connecting-wire leads have been unsoldered and appropriate screws removed. There is, however, enough space in almost all instances to permit removal of components without board removal.

The side rails of the top and bottom boards are equipped with special ground springs to ensure intimate contact with the cover. The 7 threaded inserts, which accept the 4-40 screws that hold the cover, establish fixed contact areas between shield partition and cover. A finger-stock rf seal is used where the cover and front panel join.

DB-1.4 INSTALLATION.

DB-1.4.1 GENERAL.

If the RDI-1 unit is to be added to a synthesizer, either to convert an existing step-digit station from manual control to programmable operation, or to fill out an incomplete series of step digits, observe the procedures that follow to install the unit.

DB-1.4.2 DIGIT CONVERSION.

To convert a manual-step-digit station, proceed as follows:

a. Remove the four knurled screws on the front panel of the synthesizer (accessible through cutouts in the handles), release the two cabinet clamps at the rear of the chassis, and withdraw the instrument from its cabinet.

b. Remove the two Phillips-head screws at the ends of the dial strip, along the top of the front panel, and dismount the strip.

c. Set the DI-1 unit dial knob to "5," release the two knob set screws with a 3/32-inch Allen wrench, and remove the knob.

d. Release the screw-actuated clamp bar (mounted down on the chassis), at the rear of the module, and swing the bar out of the recess in the DI-1 cover.

e. Remove the two Phillips-head screws at the top of the dial-light assembly on the front panel.

f. Work the unit off the banana-plug attachment to the chassis, lift it clear of the plugs and draw it up and to the rear, so that the dial shaft clears the front-panel.

g. Remount the dial knob on the module and store the unit carefully.

h. Continue with paragraph DB-1.4.4.

DB-1.4.3 DIGIT COMPLETION.

To complete a partially filled synthesizer with programmable step digits, proceed as follows:

a. Perform steps a and b of paragraph DB-1.4.2.

b. Remove the screw in the lower right-hand corner of the cover plate that is installed in the unused digit station and remove the plate.

NOTE

Do not remove both screws in the cover plate, or the lamp-switching assembly, behind the panel, may become dislocated.

c. Unplug the bridging unit from the digit station.

d. Continue with paragraph DB-1.4.4.

DB-1.4.4 RDI-1 MOUNTING.

To mount the RDI-1 unit in the vacant digit station proceed as follows:

a. Make sure that the Filter Plug is disconnected from the RDI-1 module, that the dial knob is removed, and that the digit-selector shaft is set with "5" marking uppermost.

b. Insert the selector shaft through the keyhole opening in the front panel of the synthesizer, place the unit over the banana plugs protruding from the chassis in the digit station, and press down gently to engage the plugs.

c. Swing the chassis clamp bar into the recess in the rear of the module and tighten the screw there.

d. Remount the synthesizer cabinet. The procedure is the reverse of steps a through f or paragraph DB-1.4.2.

DB-1.4.5 FILTER-PLUG WIRING.

The Filter Plug, FP-1, must be wired to the external programmer. For synthesizers purchased initially with programmable digits, a 50-foot roll of special 12-wire cable is furnished. For conversions or expansions this cable is recommended as an accessory available; the catalog number is 1160-9650 (50-foot lengths). See Figure DB-4 for a completed FP-1 assembly and Figure DB-5 for cable preparation details.

To wire a Filter Plug proceed as follows:

a. Remove the three Phillips-head screws on the top of the plug assembly, to release the cover, and pull it off the unit.

b. Release the two Phillips-head screws and remove the cable-clamp-and-ferrule assembly at the rear of the plug.

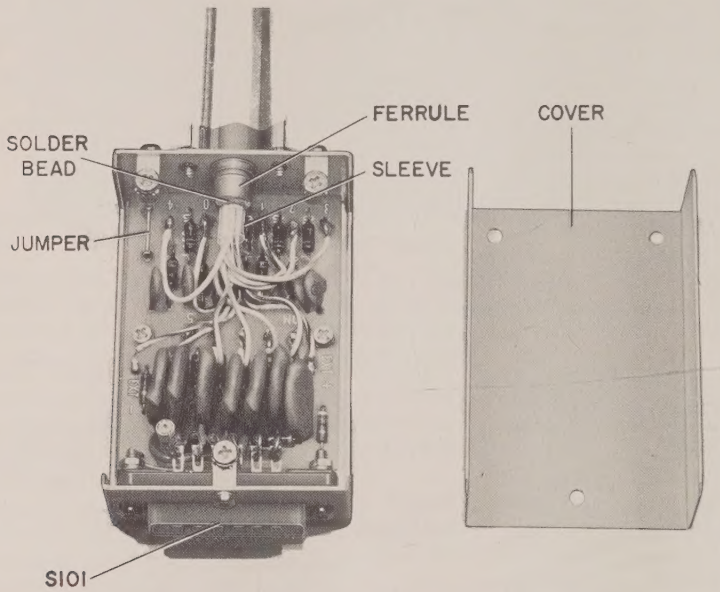

Figure DB-4.
Interior view of Filter Plug FP-1 showing remote wiring connection.

c. Remove the brass shipping clip from the clamp assembly. Carefully set aside the 3/16-inch ferrule and the 3/8-inch Teflon sleeve.

d. Insert the cable through the flanged end of the opening in the clamp, so that at least 4 inches protrudes.

e. Strip 2 1/2 inches of the grey vinyl jacket from the end of the cable, taking care not to sever the braid underneath it (see Figure DB-5).

f. Remove 2 inches of the braid, measured from the end of the cable. Take care not to unravel the Mylar sheath.

g. Expand the Teflon heat-shield sleeve just enough to allow it to pass over the Mylar sheath. Use the end of a pair of needle-nose pliers.

h. Install the Teflon heat-shield sleeve over the end of the Mylar sheath and cable, approximately 1/2 inch.

i. Pull the cable back through the clamp assembly, until the end of the jacket is 1/8-inch inside the clamp.

j. Fold the braid back over the outside surface of the clamp and trim the flared ends so that they are just short of touching the shoulder of the clamp.

k. Slip the ferrule over the end of the cable and press it over the braid, back far enough for 1/8-inch of braid to be exposed at the inside end.

l. Press the Teflon sleeve back under the clamp assembly so that no more than 1/4-inch of the sleeve is still visible.

NOTE

The ferrule should not touch the shoulder of the clamp assembly.

m. Run a solder bead completely around the inside end of the assembly to bond the ferrule to the braid and to the clamp.

n. Unravel the Mylar sheath back to the Teflon heat-shield sleeve and cut off.

o. Strip the ends of the individual leads (1/4-inch) and tin the exposed wires. Cut 1/8-inch off the ends of the tinned leads. Reinstall the completed clamp assembly in the plug.

p. Press individual leads into selected lugs and solder each one at the time of insertion. (Refer to paragraph DB-1.4.6 for sequence and lug-selection details.)

q. Dress the leads as shown in Figure DB-4. The planned slack in the leads provides service loops that permit easy alteration of the wiring at a later time, if desired.

DB-1.4.6 WIRING-CODE SELECTION.

It is recommended that the leads of the special 12-conductor cable be soldered to the lugs on the etched-circuit board of the FP-1 Filter Plug unit in order shown in Table DB-1. Note that, for the digits 0 through 8, the single color trace on the white jacket of each lead corresponds to the standard EIA color

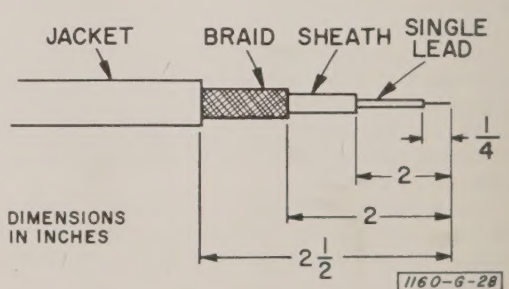

Figure DB-5.
Remote-programming control cable preparation details.

code, which should make it easier to keep the program code in sequence at the other end of the cable.

The white-with-blue-black-trace lead should be soldered to the lug marked COM, to complete the digit-selection wiring.

The two remaining leads should be soldered to lugs as indicated in the table, even if there is no planned use of external power for programmed digit selection.

TABLE DB-1

CONTROL-CABLE CONNECTION
(See Figures DB-4 and DB-18)

Lug Marking	*Lead Identification*
0	White with black trace
1	White with brown trace
2	White with red trace
3	White with orange trace
4	White with yellow trace
5	White with green trace
6	White with blue trace
7	White with violet trace
8	White with grey trace
COM	White with blue/black trace
EXT +	White with blue/brown trace
EXT -	White with black/brown trace

DB-1.4.7 FINAL INSTALLATION.

To complete the installation of a programmable-digit station, proceed as follows:

a. Reinstall the cover and plug the FP-1 on the printed-circuit connector protruding through the rear of the RDI-1 unit.

b. Thread the clamp screw on the bottom of the plug into the tapped hole in the support bar at the rear of the synthesizer and finger tighten.

c. Select an adequate length for the cable to reach the programmer and cut the cable. Attach it to the programmer, observing the color-code selections indicated in paragraph 1.5.

NOTE

The 4-inch length of aluminum channel stock supplied with the plug is a clamp-screw extender that is required only when the plug is to be used on a Type 1164 Synthesizer.

To allow for greater chassis depth of the Type 1164 Synthesizer, the extender rod should be installed in place of the swivel-mounted clamp screw on the bottom of the Filter Plug. The cutaway end attaches to the plug. Then, if the nut is remounted on the bottom of the rod at the other end, the Filter Plug can be affixed to the support bar across the rear of the synthesizer.

DB-1.5 OPERATION.

DB-1.5.1 GENERAL.

The selection of an RDI-1 digit frequency, from a remote location connected to the synthesizer by wires, is accomplished by establishing connections between these wires. As long as the dial of the RDI-1 unit is set to one of the digits 0-9, the digit frequency corresponding to this local selection is generated regardless of any existing remote-wire connection. In the "R" dial position, control of frequency is transferred to the output terminals of the FP-1 unit, from which point it may be extended as desired.

For programmed operation, the unit can be controlled by either a 10-line or a biquinary code. Digit selection can be accomplished by closure between wires by contact, by transistor switch, or other suitable means. Switching power is internally supplied normally, but provision is made for an external supply, rated at 20 Vdc, 10 mA. The time interval occuring between contact closure and the presence of a newly selected frequency is 2 ms, maximum.

DB-1.5.2 TEN-LINE OPERATION.

In the ten-line mode each digit selection is made by one closure only, consequently 10 wires (one COMMON and 9 digit leads) are required. The FP-1 is normally supplied wired for 10-line operation with the jumper AT104-AT105 installed. The code is listed Table DB-2 — all closures are to the common lead.

TABLE DB-2

TEN-LINE CONNECTION CODE FOR FP-1 FILTER PLUG
(See Figures DB-17 and DB-18)

Digit \ *Solder Terminal*	0	1	2	3	4	5	6	7	8
9									none
8									x
7								x	
6							x		
5						x			
4					x				
3				x					
2			x						
1		x							
0	x								

x = Connect terminal to COM to actuate digit.

DB-1.5.3 BIQUINARY OPERATION.

The biquinary mode of operation affords remote control with the least number of wires. One remote common lead, one shift (or HI-LO) lead and four digit

leads are all that are required. The code is listed below in Table DB-3; all closures are to the COM lead.

NOTE

Jumper AT104-AT105 must be removed when this mode of operation is desired. This jumper is located near the back (cable) end of the filter plug, see Figure DB-4.

TABLE DB-3
BIQUINARY CONNECTION CODE FOR FILTER PLUG FP-1
(See Figures DB-17 and DB-18)

Digit / *Solder Terminals*	0	1	2	3	4	5	6	7	8	9
COM	x	x	x	x	x	x	x	x	x	
8									x	
7								x		
6							x			
5						x				
4	x	x	x	x	x					
3				x						
2			x							
1		x								
0	x									

x = terminals to be connected.

DB-1.5.4 EXTERNAL RELAY POWER.

When the RDI-1 reed-relay coils are powered from the internal power supply, the open digit leads are at a potential of +18 Vdc and the COMMON lead is near instrument ground. Where these potentials are not compatible with external circuitry, they may be shifted by the use of an external supply. Filter-capacitor working voltages restrict the range to plus and minus 50 Vdc with respect to instrument ground. The diode matrix requires the polarity indicated, i.e., the positive side of the supply must be connected to the "EXT'+" terminal and negative side to the "EXT-" terminal. The limits of potentials at the "EXT" terminals are given in Table DB-4.

TABLE DB-4
EXTERNAL VOLTAGE RANGES FOR FP-1

Terminal	*Range*
EXT +	+50 to -30
EXT -	+30 to -50

Before attempting to operate the reed relays on external power, the two jumpers A-C and D-F on PL601 (back of RDI-1) have to be removed by clipping or unsoldering.

NOTE

The externally supplied relay power will be required for both remote and local control.

To cover the drop on the extra filtering for external power, 20 Vdc is the suggested operating voltage for the external reed-relay power.

DB-1.5.5 ELECTRONIC KEYING.

Where mechanical contacts are not desired, the reed-relay circuits may be closed by transistors or any other suitable electronic device. Saturated operation is suggested to keep the drop in the switch below 0.5 Vdc. Where a larger drop cannot be avoided, the currents on the leads should be measured. Currents for safe operation are given in Table DB-5.

TABLE DB-5
SAFE CURRENTS FOR RELAY CLOSURE

Digit	*Current (mA)*
8, 7, 6, 5,	3
4	6
3, 2, 1, 0 (10 line)	9

When currents called for in Table DB-5 cannot be obtained, external power for the reed relays may be used with a potential of more than 20 Vdc; neither side of the external power supply, however, can have more than 50 Vdc against instrument ground.

SECTION DB-2

PRINCIPLES OF OPERATION

DB-2.1 GENERAL.

The main circuits of the RDI-1 are shown in the block diagram, Figure DB-6 (see also the full schematic diagram, Figure DB-16).

In accordance with the flow in the synthesizer itself, where the signal is fed from DI-1 to DI-1 (from right to left), the main signal flow in the block diagram is from right to left, along the horizontal axis of the figure.

Ancillary signals, which are used in common by all DI's, consist of the 42-Mc signal to the Input Mixer and the Picket-Fence input to the Digit Phase Detector. These signals are supplied by the AFS unit (Section CA), from common busses in the Main Frame chassis (Sections BA, BB).

Operating frequencies, or frequency bands, are indicated inside the blocks of the diagram. Above the blocks, frequencies that would result from an arbitrary input frequency of 5.069 Mc/s and a digit selection of 5 are indicated as an example.

A simple numerical example will serve to explain this operation:

Since (from paragraph 4.4)

$$f_{out} = f_c + \frac{f_{s_{in}}}{10} + 10d \quad \text{kc/s}$$

and if

$$f_{s_{in}} = f_{in} - f_c$$

so that

$$f_{out} = f_c + \frac{f_{in} - f_c}{10} + 10d,$$

with

$$f_{in} = 5069 \quad \text{kc/s}$$

and

$$d = 5 \text{ (digit setting)},$$

then

$$f_c = 5000.0 \quad \text{kc/s}$$

$$\frac{f_{in} - f_c}{10} = 6.9 \quad \text{kc/s}$$

$$10d = 50.0 \quad \text{kc/s}$$

with the result that

$$f_{out} = 5056.9 \quad \text{kc/s}$$

From the comparison of f_{in} and f_{out}, it is obvious that in f_{out} a "5" has been *inserted* between the 0 and 6 of the input frequency.

DB-2.2 SIGNAL FLOW.

The input signal, 5.069 Mc/s in the example, reaches the Input Mixer through a fixed-tuned transformer. The amplified 42-Mc signal from the AFS is added here and the upper sideband is selectively amplified in the following buffer. This signal of 47.069 Mc/s is fed into the Digit Mixer, where a 100-kc multiple between 3.0 and 3.9 Mc/s is added. This "digit" signal comes from the Digit Oscillator, which is phase-locked to a particular component in the Picket Fence, as described below.

The number following the decimal point in the Digit-Oscillator frequency (in Mc/s) is the same as the number to which the digit-selector dial has been set, so that 3.0 Mc/s corresponds to "0", 3.1 Mc/s to "1", and so on. If, as in this example, the dial has been set to digit "5", then 3.5 Mc/s is added to 47.069. The resulting upper sideband of this mix is 50.569. This signal is filtered, amplified, and fed into the Divider Phase Detector.

The remainder of the main signal circuit produces, in effect, a division by 10 and as a result the

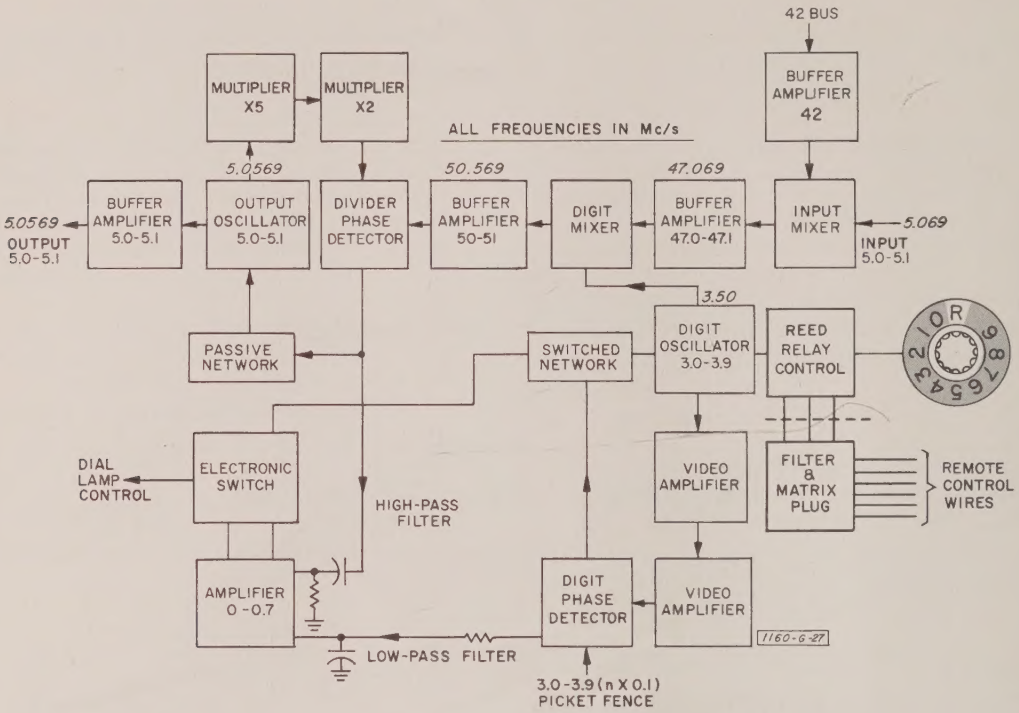

Figure DB-6.
Simplified block diagram for Remotely Programmable Digit-Insertion Unit.

Output Oscillator is now set to 5.0569. This frequency is amplified and appears at the output terminal of the RDI-1. If we compare the input and output frequencies, we note that the "69" digits in the input have been shifted to the right by one position and that a 5 has been inserted in front of them. This is the general process, which is implemented as shown by the other blocks in the diagram.

On the top right-hand side of the diagram, there is a tuned 42-Mc amplifier that takes a signal from a 42-Mc bus (generated by the AFS), amplifies it, and injects it into the balanced mixer. The main purpose of this amplifier is to provide isolation between the 42-Mc bus in the Main Frame and the Input Mixer. The 47+ signal without such isolation could enter other DI units and create spurious products.

The Digit Mixer 3.0 – 3.9-Mc input signal comes from the step-tuned Digit Oscillator, which, through amplifiers, feeds one input of the Digit Phase Detector. The reference input to this Phase Detector is the Picket Fence, consisting of a group of 100-kc standard-frequency multiples lying between 3.0 and 3.9 Mc/s. This group of signal frequencies of equalized amplitude is also supplied by the AFS.

The Phase-Detector output controls the oscillator frequency by means of varactor diodes. This phase-lock loop locks the Digit Oscillator to a frequency controlled by the primary crystal oscillator in the AFS. The Digit Oscillator is tuned approximately to one of the ten frequencies by reed relays that switch in various combinations of trimmer capacitors. The reed relays are energized either via remote wire connections or internally by a rotary switch. For the ten frequencies, the Digit Oscillator employs a tracking scheme that minimizes the number of capacitive trimmers and adjustments required. To the tuned-element sets used for the five higher frequencies, two padders are added so that the lower five frequencies fall into place with only one adjustment. Mistracking, when equalized, is 2 kc/s maximum.

Division by 10, from 50+ Mc/s to 5+ Mc/s, is achieved with phase lock in subsequent stages. The Output Oscillator signal is multiplied by 5, then by 2, and fed into a phase detector, the other side of which is fed by the filtered Digit-Mixer output frequency (in the example, 50.569 Mc/s). The Output-Oscillator frequency is varactor-controlled by the Divider-Phase-Detector output and, therefore, the frequency of the oscillator in the locked condition is one-tenth the reference frequency from the Digit Mixer.

From Figure DB-6 it can be seen that the two phase detectors have output connections to a 0 – 0.7-Mc amplifier, through high- and low-pass filters. The amplifier feeds an electronic switch. As long as ac signals in the passband of the filters are present, the switch is open and the bandwidth of the switched network is wide. This is the condition prior to capture; after capture, the ac components disappear, the switch closes, and the bandwidth is narrowed. Reduction of bandwidth is necessary in the digit phase lock, where all pickets are present simultaneously to minimize 100-kc spurious sidebands. "Capture" is indi-

cated by the dial light, which is extinguished if either oscillator fails to lock.

DB-2.3 CIRCUIT DETAILS.

DB-2.3.1 GENERAL.

Circuits, and the location of prominent components, will be discussed in the sequence in which the signal passes through a Digit-Insertion unit. Reference will be made to the block diagram Figure DB-6, as well as the over-all schematic diagram, Figure DB-16. Figure DB-7 will be a useful reference for physical identification of the circuits discussed.

DB-2.3.2 INPUT SECTION.

The input section consists of an Input Mixer preceded by a 42-Mc Buffer and followed by a 47 – 47.1-Mc Buffer. The 42-Mc Buffer is a common-emitter stage, Q306, with a tuned output coil, L303, that serves as isolator, amplifier, and impedance transformer for the 42-Mc signal from the AFS. This signal is taken from the 42-Mc bus, through J306, and processed for injection at the Input Mixer. The input network of the buffer is of moderately high impedance and is broadly tuned.

The Input Mixer combines the incoming 5.0 – 5.1-Mc signal from J305 and the 42-Mc signal from the buffer. The 5.0 – 5.1-Mc input, of approximately 0.30 V, is stepped up in T302 and applied to Q303 and Q304. The connection between L303 and T302 feeds the 42-Mc signal to the transistors in-phase and also completes the bias circuit. The balanced configuration, together with the circuit (T303, C314, C315) tuned to the upper sideband (47 – 47.1 Mc/s), effectively eliminates the 42-Mc component in the output and provides substantial rejection for the ninth-harmonic component of the 5 to 5.1-Mc input signal.

Q305 is a transformer-coupled buffer-amplifier which amplifies the 47 – 47.1-Mc signal for application to the Digit Mixer. Tuned output coil L306 further contributes to the selectivity provided for the suppression of unwanted mixer-output components.

The input circuits described above occupy the front right-hand side of the bottom circuit board (see Figure DB-7).

DB-2.3.3 DIGIT MIXER AND 50 – 51-Mc BUFFER.

Wire links, joined through the central shield partition by AT502, bring the 47 – 47.1-Mc signal from the Q305 buffer stage to C103 and C104 (at the rear of the top board), which form the input to the Digit Mixer. The second signal into this mixer is the Digit-Oscillator output of 3.0 – 3.9 Mc/s, in 100-kc steps. The resultant output of 50 – 51 Mc/s (47 + 3.0 to 47.1 + 3.9 Mc/s) is filtered in the tuned circuit T101/C105 and applied to the following buffer, Q103. To obtain an equalized output over the 1-Mc bandwidth, a double-tuned filter (compensating the response of the preceding single-tuned circuit) couples the signal into the Divider Phase Detector.

The Digit Mixer and Buffer circuits are located on the top board at the back end (see Figure DB-7).

DB-2.3.4 OUTPUT OSCILLATOR/MULTIPLIER.

The output signal of 5.0-5.1 Mc/s is generated in a Colpitts oscillator (Q104). The tuned circuit includes the varactor diode, CR103, which makes the oscillator voltage-tunable.

Transistors Q106 and Q107 perform the multiplication of the oscillator frequency by ten. Both are class-C multipliers that are tuned to the desired harmonic of the input frequency in the respective collector circuits. L107/L108 are resonated at approximately 25.25 Mc/s and T104/T102 are tuned to about 50.5 Mc/s.

The above circuits, from the oscillator through the multipliers into the Divider Phase Detector (a conventional half-bridge circuit), and from its output through filter circuits back to varactor-diode CR103, form a phase-lock circuit. Once captured, the oscillator frequency is kept at exactly 1/10th the reference frequency (50-51 Mc/s) by a dc voltage applied to the varactor diode. This voltage is developed in the phase detector.

If a different dc voltage is required on the varactor diode, to compensate for circuit drifts in the oscillator for instance, only the relative phases of the two inputs to the phase detector change. Potentiometer R109 sets the initial back-bias for the varactor diode and, therefore, affects the free-running oscillator frequency.

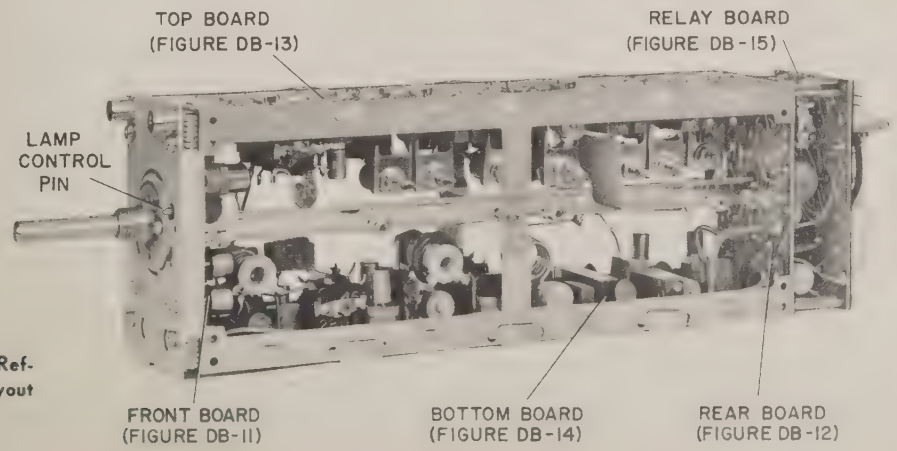

Figure DB-7.
RDI-1 module with cover off. Referenced figures give circuit-layout details.

During the process of capture (the synchronization of the oscillator frequency with the reference frequency), the oscillator is frequency-modulated initially with the frequency difference between the reference and its own frequency multiplied by ten. Sidebands of this modulation have to be passed by the multiplier circuits and they are therefore considerably wider in bandwidth than the 5-5.1 or 50-51 Mc/s would suggest.

The Output Buffer, Q105, is a broadly tuned, common-emitter stage following the oscillator. The output voltage of approximately 0.30 V, rms, is fed to J304. Note that the contact associated with J304, as well as the contact near the input (J305), is not internally grounded. Ground springs on the Main Frame connect both the output and input ground contacts of adjacent DI-1 units. The fact that the springs are connected to the chassis in only one place increases the isolation of the input and output circuits, since the chassis has to carry no current.

The Output Oscillator, Output Buffer, and multipliers are located in the front half of the top circuit board (Figure DB-7).

DB-2.3.5 DIGIT-OSCILLATOR PHASE LOCK.

The Digit Oscillator provides injection frequencies to the Digit Mixer, which are the crystal-locked 100-kc steps between 3.0 and 3.9 Mc/s. While all of these frequencies are present simultaneously in the Picket Fence (generated in the AFS), only one specific frequency is required for each setting of the digit-selector dial (S201). All others must be kept out of the Digit Mixer, in order to avoid spurious outputs. The selection and filtering of the proper Picket-Fence frequency is achieved by a step-tuned oscillator and a phase-lock loop.

Colpitts-oscillator Q201 is tuned to each of the ten frequencies by relay-selected trimmer capacitors, C201 through C205. C205 is always connected and is used alone to adjust the 3.9-Mc top frequency initially (digit-selector setting 9). Digits 8, 7, 6, and 5 are set by C204, C203, C202, and C201, in that order. At this midband point, a pair of padder capacitors (C211 and C212) is added as shown to select digit 4 and the lower digits. After adjustment of the 3.4-Mc frequency with C211, the lower frequencies are obtained automatically with the same trimmer-capacitor settings used for the corresponding higher frequencies. The circuit inductance, T201, is preadjusted to the proper value so that tracking errors are kept below ±2 kc/s. As in the Output Oscillator, part of the C in the tuned circuit is represented by voltage-variable capacitance (CR201 and CR202), to obtain phase-lock capability.

Reed-relay coils K601L to K605L are all connected to the positive (+18 Vdc) supply on one side; completion of the circuit to ground from the other end of the coil will close the relay contact and select a particular digit. S601 closes these circuits in positions 0-9. In the "R" position the "REMOTE COMMON" lead is grounded, so that relay coils may be energized by connection of a digit wire to the REMOTE COMMON lead externally.

To avoid signal radiation and cross-coupling, remote wires are passed through filter plug FP-1 before leaving the instrument. Housed in the same enclosure is the diode matrix used to convert from the biquinary to a 10-line code (see Figure DB-18).

Two video-amplifier stages, Q301/Q302, amplify the oscillator signal for injection into the Digit Phase Detector. The reference side of the phase detector is transformer-connected (T301) to the balanced Picket-Fence bus in the Main Frame. The phase-detector control-signal output is filtered and applied to the varactor diodes, CR201 and CR202. If the Digit-Oscillator free-running frequency deviates from the chosen crystal-derived Picket-Fence frequency, the phase of this oscillator signal shifts, until the phase detector produces enough dc output to correct the oscillator frequency by means of the varactor diodes.

Picket frequencies to which the oscillator is not locked produce 100-kc, 200-kc, etc, outputs from the phase detector that would frequency modulate the oscillator, if not suppressed. Consequently, sufficient attenuation of these signals and retention of adequate capture range are conflicting requirements. The filter, in the "CONTROL" line between the phase-detector output and the oscillator varactor diodes, therefore, operates in two modes, as selected by the filter-switching circuit (Q403-Q405). The filter passband is wide for the capture process and narrow for normal operation, after capture has been attained. The normal back-bias for the varactor diodes is established by potentiometer R311.

The RDI-1 output frequency changes 10 kc/s for every 100-kc step of the Digit Oscillator or 90 kc/s for the total Digit-Oscillator range of 900 kc/s, because of the division-by-ten following the Digit Mixer. The 100-kc range, from 5.0-5.1 Mc/s in the input frequency, is reduced to 10 kc/s in the output for the same reason. This means that 90% of the signal supplied as reference to the Divider Phase Detector comes from the Digit Oscillator and only up to 10% from the input signal.

Thus, the Digit Oscillator setting can be used to preset output-oscillator tuning in the correct general region for easy capture. The feedthrough (via AT504) from the Digit Oscillator through R206 and R127, to the arm of R109, shifts the free-running frequency of the Output Oscillator. By variation of the dc bias on the varactors, it is shifted from approximately 5.025 Mc/s (for digits 0 through 4) to approximately 5.075 Mc/s for digits 5 – 9.

The Digit Oscillator is located on the rear board, while the two video stages and the Digit Phase Detector occupy the rear half of the bottom board (see Figure DB-7).

DB-2.3.6 LOCK SENSING AND FILTER SWITCHING.

Capture of the two phase-lock loops, the divider main loop and the digit-oscillator loop, is monitored by the lock-sensing and filter-switching circuit. The input amplifiers, Q401 and Q402, are connected to the phase detectors to amplify ac output signals present. Any two signals that enter the phase detectors without achievement of lock will produce an ac output that

corresponds to their frequency difference. This output is applied to the voltage-doubler-rectifier, CR401/CR402, and is used to cut off transistors Q403 through Q405. This will (in turn through the lamp-control pin) extinguish the dial lamp on the front panel, to give warning of malfunction.

In the normal condition of this switch, stages Q403 through Q405 are turned on, effectively shorting C306 in the filter network that follows the Digit Phase Detector. This effect introduces a low-frequency cut-off network (R315, C306) and lowers the loop gain by the loading of the phase-detector output with R314.

If the Digit Oscillator is now switched to a new frequency (which might be slightly off from the crystal-derived Picket Fence) the beat note, through R306-R401, will be applied to the amplifiers and open the switch. This will unground C306 and thereby shunt R315 with R314. The bandwidth is widened, the load is removed from the phase detector, and capture can now be attained. As the beat note disappears from the phase-detector output after capture, the switch will return to the normal, closed position.

R306/C301 and R401/C402 form a low-pass filter to prevent the 100-kc beat note, which is always present in the Digit Phase Detector due to adjacent pickets, from opening the switch.

DB-2.3.7 DIGIT-SELECTION CIRCUITS.

The RDI-1 dial has an 11th position marked R, in which frequency selection is made by contact closure on remote leads. If the dial is moved from the R position, manual selection overrides.

Selection of a digit in the RDI-1 is accomplished by the change of frequency in the Digit Oscillator. Capacitors in that circuit are switched by low-loss, rf-type reed relays. The reed driver coils are energized from the internal supply but can also be operated from an external supply. To select a particular digit, establish connection between the designated digit wire and the common lead.

A magnetic reed relay is a normally open reed switch, surrounded by a small electromagnetic drive coil. The reed switch is a glass capsule, containing two permeable reeds in a nitrogen atmosphere. When the drive coil is energized, the reeds snap closed. Coil actuation is limited to low-ripple-current dc.

The inherent simplicity of the dry-reed-switch structure is one key to its long life and reliability. The switch consists of two reeds, of a ferro-magnetic material, inserted into opposing ends of a glass tube in a cantilever fashion. The internal ends of the reed are overlapped, the glass envelope is fused to the reed shanks, and a fixed air gap is established between the cantilever beams. The sealing process is performed in the presence of dry inert gas to ensure contact operation free from surface contamination and oxidation. In use, when a magnetomotive force is applied by the coil the reed becomes a flux-carrying element in the magnetic circuit. The contact ends assume opposite polarity and snap together, closing the switch.

The reed relays are directly associated with rf circuitry in the digit oscillator. An internal two-section filter is used to reduce rf voltages on the remote wiring, to approximately 50 μV. In addition, the recommended cable has a grounded shield to prevent RFI.

The components of this filter are housed in a small, separate, plug-in shield engaging a connector that protrudes from the rear of the RDI. This filter plug also contains the diode matrix that facilitates conversion from an internal biquinary code to a 10-line code. The unit can be remotely programmed in either code; the filter plug is normally wired for 10-line, but removal of one jumper wire converts it to the biquinary code.

In the latter mode of operation, the digit 9 is produced with no external closures; 8, 7, 6, 5 are selected by connection of the appropriate wire to the common wire. The lower digits 4, 3, 2, 1, 0 are obtained with the same closures used already for the higher digits but with the additional closure of a range (or shift) wire to common. The 8 wire produces digit 3 when connected to common, 7 selects digit 2, and so on. In the 10-line mode, where one wire corresponds to each digit, the digit 9 is also selected with no closures. The 12 leads in the cable supplied are the maximum needed (10-line with external power).

A device is suitable for direct connection to the RDI-1's if it provides either mechanical or electrical contact closure in the 10-line or biquinary form and maintains continuous closure as long as a particular frequency setting is desired.

If a transistor switch is used, voltage drop must not exceed 0.5 volt for currents from 3 to 9 mA. The internal supply places the common lead at ground potential, whereas the open leads are at +18 volt with respect to ground.

For operation with external supply, two jumper wires must be removed. This should facilitate direct tie-in with existing equipment, particularly with transistor-switch outputs.

Programming by digital equipment in binary-coded decimals may require external storage, if entry is in serial rather than in parallel form.

Reed-relay switching time is within 2 milliseconds. This is the time interval between the external contact closure and the presence of the newly selected frequency. The actual transition from one frequency to another can be appreciably faster as seen in Figure DB-8, which shows a switch from 9.0924 kc/s to 2.0361 kc/s. The heavy trace is the voltage across the external contacts (of the first digit). The lower portion shows closed contact (0 volts) and the upper portion open contact. Time scale is 2 ms/cm.

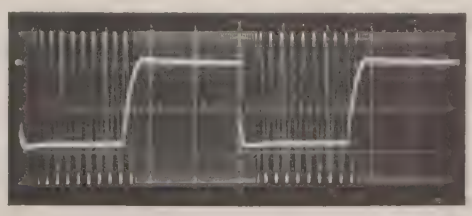

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Figure DB-8. RDI-1 output-frequency switching-time capability.

SECTION DB-3

SERVICE AND MAINTENANCE

DB-3.1 INTRODUCTION.

If the system self-check procedures of Section 5 (front part of the manual) indicate that service is required for an RDI-1 unit, remove the unit from the chassis (paragraph 5.4.2) and replace it with a bridging unit (paragraph 5.5.1).

It is recommended that the unit be returned for service to the General Radio Company (particularly within warranty). Where this is not possible, certain tests can be made in the field, but a thorough understanding of the principles of operation is essential (refer to Section DB-2 above).

The procedures that follow will permit isolation of the fault, so that corrective measures can be taken. Since the synthesizer Main Frame can be used as a test fixture, refer to the appropriate Main Frame chassis schematic (Section BA or BB), as well as to the over-all schematic for the unit, Figure DB-16.

NOTE

Reference is made to banana plugs and other test points on the Main Frame by the designations used in Chassis 1160-4060.

DB-3.2 TEST EQUIPMENT.

Table DB-6 lists recommended test equipment required to test the RDI-1 module. Equivalent equipments may be substituted.

DB-3.3 TROUBLE ANALYSIS.

DB-3.3.1 GENERAL.

CAUTION

Turn power off during set-up changes to avoid accidental short circuits, which can blow F503 in the Power Supply module (PS-1).

Remove the malfunctioning RDI-1 unit from the Main Frame and withdraw the unit from its cover, after removal of the three 4-40 screws on each side. Reinstall the open unit (complete with dial lamp) carefully in station VII, next to the CAD unit. Do not install Filter Plug FP-1. Remove the CAD unit, as in paragraph 5.4.3 (front part), as well as the DI unit in station VI. Do not install a bridging unit in this space. The Calibrating Mixer module does not have to be removed.

Use Figures DB-9 and DB-10 to locate interior test points, which for the most part are simple wire loops in the top circuit board of the unit.

DB-3.3.2 POWER INPUT.

With the VTVM look for +18 ±0.2 Vdc at AT205 on the rear circuit board. If the indication is abnormal, check the distribution of this supply voltage in the Main Frame chassis and this output of the Power

TABLE DB-6
TEST EQUIPMENT

Function	*Type Recommended*	*Minimal Characteristics*
Electronic Voltmeter (VTVM)	GR 1806 (with 1806-P1 probe)	BW 1-55 Mc/s; sensitivity 0.2 V; probe capacity 2.0 pF maximum
Digital Frequency Meter	GR 1143 or 1144	Dc to 50 Mc/s; resolution 100 c/s; sensitivity 0.1 V; input impedance >500 ohms
Oscilloscope	Tektronix 543 (with C/A plug-in and P6006 10× probe)	20 Mc/s, 0.5 V/cm, 8 pF (or less) probe.

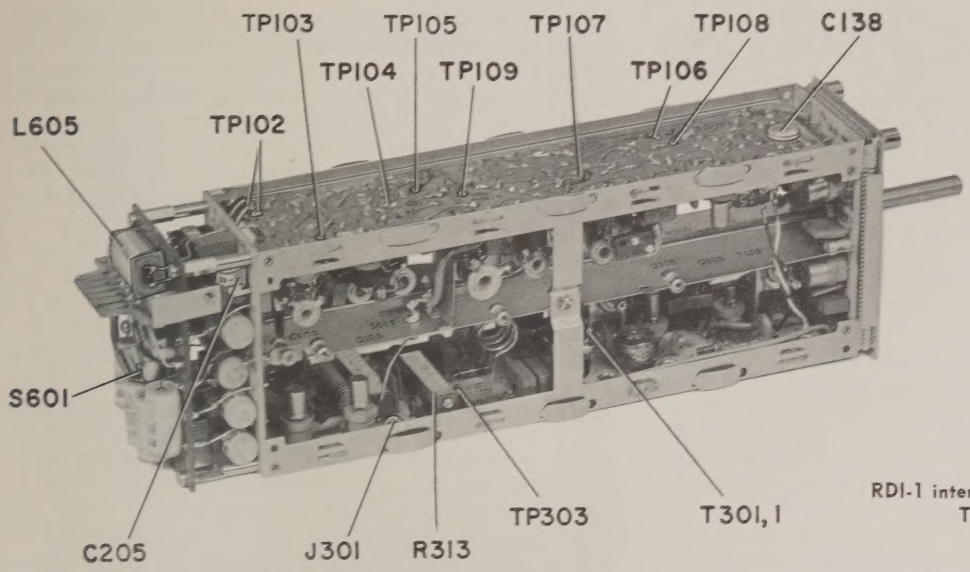

Figure DB-9.
RDI-1 interior test points and adjustments
Top left oblique view.

Supply module. If the indication is normal, continue with the procedures below.

DB-3.3.3 OUTPUT OSCILLATOR/OUTPUT BUFFER.

Connect the oscilloscope or the VTVM between PL212-6 and the ground spring on the top deck of the Main Frame, to the left of the RDI-1 under test. Depress the CAD OFF button and turn the POWER switch on. An rf voltage of 0.2 to 0.4 V, rms, should be present. If no indication is obtained, or if inadequate voltage is observed, the Output-Oscillator (Q104), or the Output-Buffer (Q105) circuit, is probably faulty.

DB-3.3.4 PHASE-LOCK LOOP TESTS.

If the proper output voltage was present in the preceeding test, confirm that an input signal to the RDI-1 under test is present at PL213 on the Main Frame top deck. This should be about 0.3 V, rms, at 5.0 Mc/s.

Then, connect the digital frequency meter to PL212-6 (connects with J305 on RDI-1) and observe the output frequency corresponding to various dial positions of the DI unit. A properly functioning unit would indicate 5.0100 Mc/s for digit 1, 5.0200 Mc/s for digit 2, and so on. If steps of nearly (but not exactly) 10 kc/s are obtained, the main loop is functioning properly, but the digit-oscillator loop is not locked.

If, however, the frequency does not move in steps of exactly 10 kc/s in accordance with the dial, or if only certain of the frequencies (like 5.0500 Mc/s for digit 5) are obtained exactly and others are off, the main loop is out of order. (Operation of the digit phase-lock loop cannot be tested at the output of the DI unit, where the counter is connected, as long as the main phase-lock loop is out of order).

Indications of the dial lamp will permit further conclusions about the two phase locks. If the dial lamp is extinguished while an improper frequency is shown, both signals into the Divider Phase Detector are present but they are not locked. This may be due to low signal level or to improper free-running os-

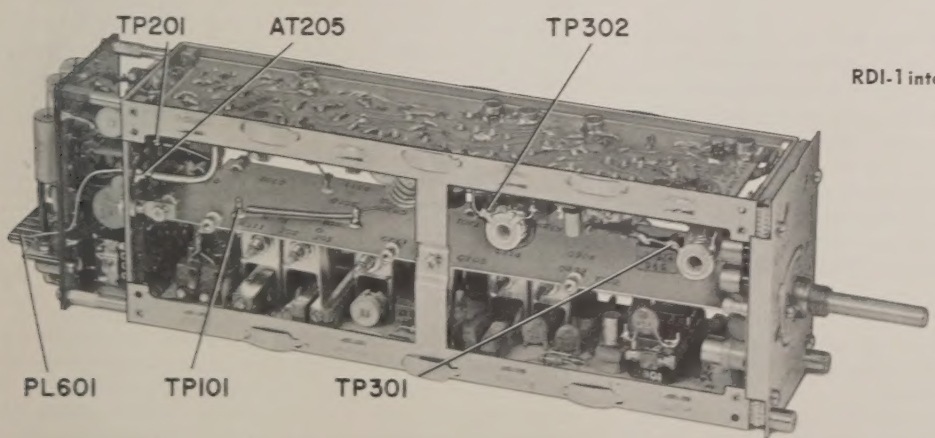

Figure DB-10.
RDI-1 interior test points and adjustments.
Unit shown inverted.

cillator frequency. If the lamp remains turned on, however, lock failure is probably due to lack of at least one of the input signals to the phase detectors. The dial-lamp sensing circuits monitor both the divider phase lock and the digit phase lock.

Depending upon which of the two phase-lock loops is suspected of malfunction, select the appropriate procedure among the two that follow.

Output-Oscillator (C138) trimmer, and Digit-Oscillator (C205) trimmers, are accessible through the top cover. It is sometimes possible to correct oscillator frequencies (as a temporary measure) by tuning the proper capacitor until lock is achieved (dial lamp will relight). Verify operation with the counter and set the trimmer to the mechanical midpoint of the capture range. Determine capture range by turning the unit on and off with the power switch, while altering the trimmer position in small steps until lock (proper frequency and lamp "on") can no longer be attained.

DB-3.3.5 MAIN-LOOP TESTS.

The main loop is comprised of the majority of the circuits in the RDI-1 and includes: the Input Mixer, the 42-Mc Buffer, the 47/47.1-Mc Buffer, the Digit Mixer, the Digit Oscillator (without its phase lock), the 50/51-Mc Buffer, the Divider Phase Detector, the Output Oscillator and Buffer, and the X5 and X2 Multipliers.

Output-Oscillator Free-Running Frequency

Depress the button under the CAD unit. Connect TP104 to TP105 with a 10-ohm resistor (use Alligator clips), to disable the phase detector. Turn the power on and observe the output-oscillator free-running frequency with the digital frequency meter connected to PL212-6, as before. The indication should be 5080 ±3 kc/s for digit settings 9 through 5, and 5030 ±3 kc/s for digit settings 4 through 0. Reset the frequency with C138, if necessary.

This test can also be performed without a digital frequency meter, if a working CAD unit and the Calibrating Mixer are used instead as a frequency meter. To do this, install the CAD unit in the chassis in the usual manner. Connect TP103 in the RDI-1 to case ground, with a short clip lead to prevent signal leakage, and use the 10-ohm resistor between TP104 and TP105, as described above.

To compare frequencies, set the front-panel MONITOR switch to CAD CAL, push the CAD substitution button under the RDI-1 to be examined, and tune the CAD for a null indication (or a slow beat) on the meter. With the CAD in the INTERNAL LOCK mode, the significant last two digits can be read directly on the CAD dial; 5030 kc/s will read as 30 on the CAD dial, etc. Remove the CAD after this test; the Calibrating Mixer can remain. Also remove the 10-ohm resistor and the ground lead at TP103.

Divider-Phase-Detector Input (Oscillator Side)

If the Output Oscillator is operative, the next step is to check the Divider-Phase-Detector input, and then work back from there.

To do this, first depress the button under the CAD unit. Since the CAD is not installed in the Main Frame, there will be no input to the RDI-1 under test (in Station VII) and, therefore, there should be no signal at TP104. Connect the VTVM (15-V scale) between case ground and TP109; a 50-Mc voltage of 3 to 4 V should be present.

If not, measure the voltage at TP107, which should be approximately 1.6 to 2.2 V at 25 Mc/s. The output oscillator amplitude measured at TP106 should be 2.5 to 2.9 V at 5 Mc/s.

Divider-Phase-Detector Input (Reference Side)

Retain the test conditions of the previous paragraph to measure the input to the Divider Phase Detector. Ground TP108 to disable the Output Oscillator. Depress the CAD OFF button, thus restoring an input signal at 5 Mc/s to the RDI-1, and measure the voltage from TP104 to ground. A signal of 2.5 to 3.5 V at 50 Mc/s should be obtained, which peaks for the middle digits and drops about equally for digits 0 and 9, when the digit-selector dial is operated.

Voltages obtained at TP103 should be 0.5 to 0.8 V, with a peak at digit 5. Connect the digital frequency meter to TP103 to measure frequency. Care should be taken not to measure the image frequency of the Digit Mixer (43.5 Mc/s instead of 50.5 Mc/s for digit 5).

The Digit-Oscillator output-signal amplitude measured at TP201 is 2.5 to 2.9 V, depending on digit setting, or approximately 1 V at TP102 (both meter leads). The second injection into the Digit Mixer is the 47+ Mc signal, 1.6 to 2.5 V, at TP101.

At TP302, 0.8 to 1.3 V of 47+ Mc/s is normally obtained; at TP301, 0.5 to 0.7 V of 42 Mc/s is present.

DB-3.3.6 DIGIT-OSCILLATOR LOOP TESTS.

The Digit-Oscillator loop includes the Digit Oscillator, the two video buffers (Q301/Q302), the Phase Detector, and Picket-Fence input transformer (T301).

Digit-Oscillator Frequency (Free-Running)

To measure the Digit-Oscillator free-running frequency, the Picket-Fence generator in the AFS has to be disabled by removal of the link between terminals 5 and 6 of L501 in the Power Supply module (component side of the etched-circuit board on top of the coil; refer to Section GA). With a properly functioning main loop, the output frequency obtained at PL212-6 for a setting of 9 is 5.0900 Mc/s (CAD OFF button depressed). Reset the RDI-1 to this frequency with C205, if necessary.

High resistance in the reed contact could raise the frequency of the 0-4 digits (K605SA or K605SB) or of a digit pair, like 3 and 8 (K601S through K604S). Operation of the reed relays may be tested at this point. The proper frequencies corresponding to the digit settings are given in Table DB-7.

Before deciding to replace reed relays, be certain to distinguish between general oscillator frequency drift, which affects all digits to approximately the same degree, and a reed failure, which shows frequency discrepancies on a pair of frequencies or the

lower digits only. Since the capture range on all digits is approximately 1.5 kc/s, deviation in frequency would have to exceed this figure before a lock failure, extinguishing the dial light, would occur. With remote frequency control, it is essential to distinguish between faults inside the RDI-1 and faults in the FP-1 Filter Plug, or the remote wires and switches. If the RDI-1 Digit Oscillator produces the correct frequencies (as listed in Table DB-7) with the *manual* digit-dial settings, the digit oscillator and the reeds are operative, and the fault is outside the RDI-1 proper.

If several RDI-1's are in the chassis, substitute the FP-1 Filter Plug and remote wiring from a properly operating RDI-1, to isolate the malfunction.

TABLE DB-7

RDI-1 OUTPUT FREQUENCIES

Dial Setting	*Frequency (±0.3 Kc/s)*
9	5090.0
8	5080.0
7	5070.0
6	5060.0
5	5050.0
4	5040.0
3	5030.0
2	5020.0
1	5010.0
0	5000.0

Digit-Phase-Detector Injection (Oscillator Side)

With the Picket Fence disabled as above, measure the amplified oscillator voltage at L301 via TP303; it should be 6 to 8 V.

Digit-Phase-Detector Injection (Reference Side)

Reconnect the link on the power-supply +18 V bus (L501, 5-6) to the Picket Fence circuitry to measure the input signal at T301. Short TP201 to ground, to disable the Digit Oscillator. A peak-reading VTVM will indicate 20 – 30 V at terminals 1 or 6 of T301.

DB-3.4 DC VOLTAGE CHECKS.

The procedures of preceding paragraphs should narrow the search for circuit defects to a circuit function consisting of one or, at most, a few stages. As a further aid to pinpoint the defective part, the information on dc voltage readings is presented in Table DB-8.

DB-3.5 REPAIR AND REPLACEMENT.

Replace defective detail parts (with frequency-insensitive functions) to correct deficiencies indicated by the trouble-analysis procedures.

CAUTION

Replacement of frequency-determining parts will require realignment which cannot be accomplished without special test fixtures.

Figures DB-11 through DB-15 show the physical layout of parts on the various etched-circuit boards of the RDI-1 units, to speed positive identification. The reference designators for the parts shown on the boards are the same as those used in the over-all schematic diagram, Figure DB-16, and in the parts list at the end of this section.

If the switch portion of the reed relay becomes defective and must be replaced, proceed as follows:

a. Snip the leads at the bend, at both ends of the relay.

b. Leave the lead stub on the board, but bend it slightly at the outside end of the relay, to permit clearance for the switch portion.

c. Grasp the switch portion with a needle-nose plier, by the remaining lead end, and pull the switch out of the coil.

To install the replacement:

a. Slide the switch into the opening in the coil, align the axial leads with the lead stub from the board, so that they are touching.

CAUTION

Handle the switch lead gently to protect the glass seal.

b. Snip off the surplus lead length and solder the junction.

NOTE

The leads on K605S should not be bent nor trimmed shorter than 5/16 inch, as they are part of the over-all magnetic circuit in the relay.

TABLE DB-8

TYPICAL DC VOLTAGES

Transistor	*Emitter*	*Base*	*Collector*
Q101	1.1	0	17.8
Q102	1.1	0	17.8
Q103	1.25	1.4	17.7
Q104	16.0	15.5	0
Q105	17.8	17.5	0
Q106	3.0	0	17.7
Q107	1.75	0	17.2
Q201	16.2	15.7	0
Q301	11.5	11.2	5.1
Q302	15.0	14.5	0
Q303	17.6	17.8	0
Q304	17.6	17.8	0
Q305	0.5	0.95	17.5
Q306	0.7	1.30	17.7
Q401	4.0	4.7	11.3
Q402	11.5	11.2	8.5
Q403	1.1	0.90	0.73
Q404	1.25	1.05	1.1
Q405	1.3	1.10	1.25

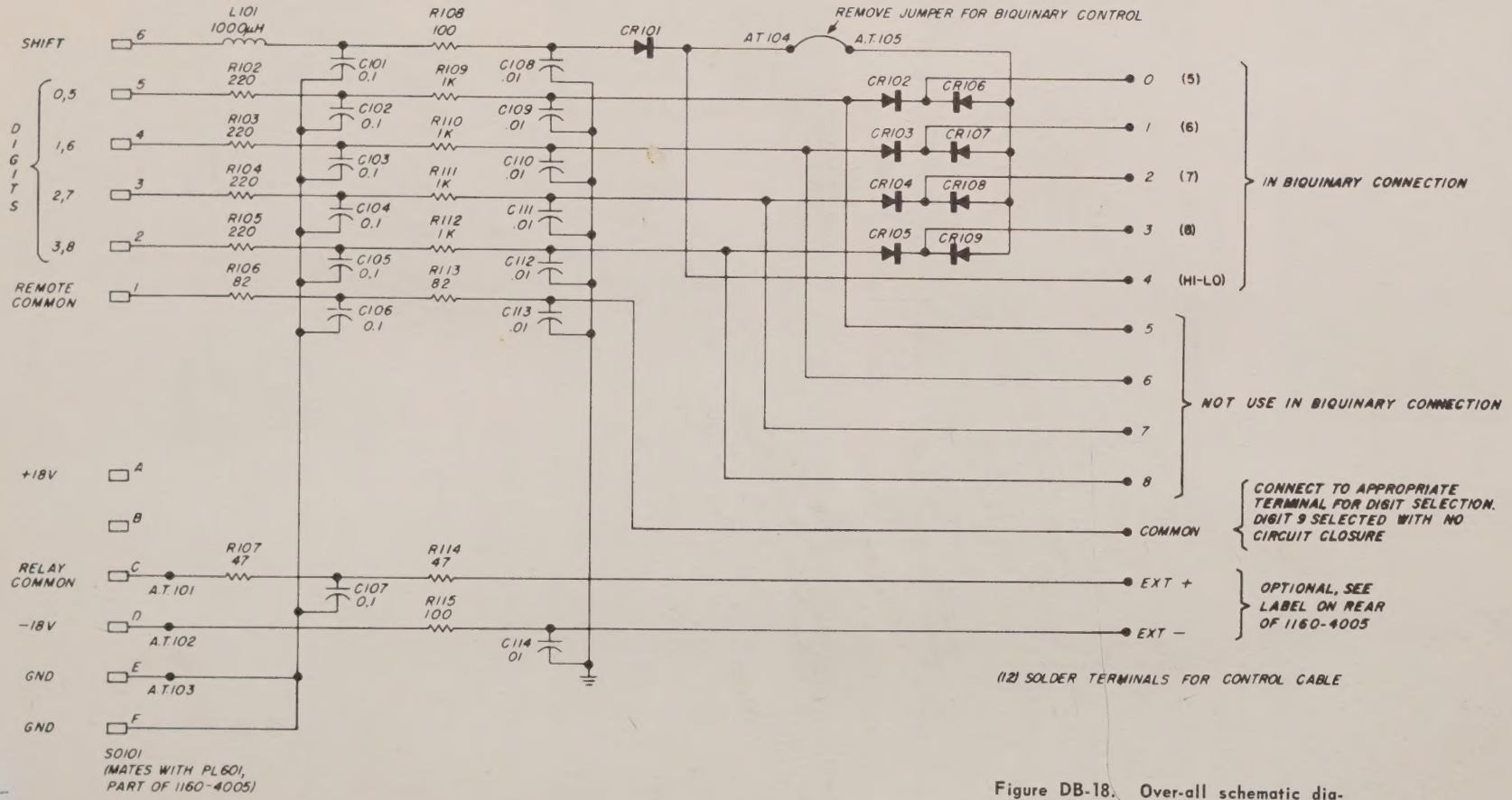

Figure DB-18. Over-all schematic diagram for Filter Plug FP-1 (P/N 1160-4090)

NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM
4. RESISTORS 1/4 WATT
5. RESISTANCE IN OHMS K - 1000 OHMS M - 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS
7. ◯ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP - TEST POINT

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